**Lab Investigation: Density of a Solid**

Student name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Chemical background: How is density related to atomic structure**

The first order determinate would be the atomic mass, with elements of higher atomic mass being generally denser.  Gold is just short of 197 amu, Lead is 207 amu, only about a 5% difference.   The density of gold is 19.32 grams cubic centimeter vs. lead at 11.34 grams per cubic centimeter for a 7% difference in the opposite direction.    
Looking at the electron structure, we find that gold and lead are identical, both are in period 6. However; gold has one electron in the 6s orbital, whereas lead has two electrons in the 6s orbital PLUS two more in the 6p orbital.  This means that the lead atom is considerably larger than the gold atom because it had to add an outer orbital to make room for the last two electrons.  Therefore, although slightly heavier, the lead atom is also quite a bit larger (and therefore less dense) than the gold atom.  This is confirmed by the relative bond lengths: an Au - Au bond is 288pm, whereas the Pb - Pb bond is 350pm.  Therefore, the gold atoms are closer together and the Therefore, although slightly heavier, the lead atom is also quite a bit larger (and therefore less dense) than the gold atom.  This is confirmed by the relative bond lengths: an Au - Au bond is 288pm, whereas the Pb - Pb bond is 350pm.

**Introduction:**

An important physical property, which is useful in characterizing substances, is the property of density. The density of a substance is defined as its mass per unit volume, and can be written mathematically as:

Density = Mass ÷ volume or D = m/V

Density is an ***intensive*** property, which means it does not depend on the amount of substance present whereas volume and mass are ***extensive*** properties because they depend upon shape and size.

For example, one gram of lead would have the same density as one ton of lead.

As a result, density can be used as one characteristic to identify an unknown metal.

**Procedure:**

1. Obtain a metal sample, and using an electronic balance, determine its mass.
2. Pour into a 250 mL graduated cylinder enough water to cover the metal when it is placed into the cylinder. Record the volume of water in the graduated cylinder before adding the metal.
3. Next, add the metal to the graduated cylinder by slowly sliding it down the side. Make sure not to splash any water onto the side of the graduated cylinder. The water stuck on the side can be a source of error and can cause your results to be wrong. Check to ensure that the metal traps no air bubbles. If there are air bubbles present, gently tap the sides of the cylinder to release them.
4. Record the volume of the water plus metal. Dry the metal as thoroughly as possible using paper towels. Repeat the experiment with two other metals provided by the instructor. Identify your samples by using the density you determined and the density table below:

**Density of Metals**

**Aluminum 2.70 g/ cm3  
Brass 8.40 g/cm3**C**admium 8.69 g/cm3  
Copper 8.92 g/cm3Gold 19.3 g/**

**cm3  
Iron 7.87 g/cm3  
Lead 11.29 g/cm3  
Magnesium 1.74 g/cm3  
 Silicon 2.23 g/cm3  
 Silver 10.50 g/mL   
Steel 7.85 g/mL   
Tin 7.28 g/mL   
Tungsten - 19.3 cm3  
Zinc 7.14 g/mL Lab**  
Lab Investigation: Density of a Solid—Pre-lab questions

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| 1. How is atomic radius determined? |
| 1. What is an “amu” ? |
| 1. How many electrons fit into a “p” orbital? In what directions? |
| 1. Is density an extensive or intensive property? Explain. |
| 1. What is the formula for density and what units are usually used to express it? |
| 1. What is the purpose of this experiment? |
| 1. Procedure: Summarize the procedure in 2-3 sentences using passive voice. |

**Data Collection:**

Title of Data Table: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| --- | --- | --- | --- | --- | --- | --- |
| Sample number, description and color | Mass (grams) | Volume of Water Before Adding Metal (mL) | Volume of Water After Adding Metal (mL) | Difference in Volume (Volume of Metal—mL) | Density  g/mL | Identity of metal |
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**Lab Investigation: Density of a Solid Calculations:**

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| 1. Calculate the density of each metal by using the formula: Density = mass/volume. |
| 2. Use the known densities to identify your unknown metal. |
| 3. Using the accepted value and your experimental value, calculate the percent error for your metal.    Repeat all your calculations for each type of metal that was tested. |

**Post-Lab Questions:**

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| 1. Can you use the water displacement technique to find the density of any solid? |
| 2. Besides measuring incorrectly or performing calculations wrong, what are three other sources of error that are inherent in the technique? |
| 3. What can you change in the lab to minimize the error? |
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